REMARKS

Claims 1-3, 8-9 and 11 are pending in this application. The Office Action rejects claims 1-14. By this Amendment, claim 1 is amended and claims 4-7, 10 and 12-14 are canceled. Support for the amended claims can be found in the specification and in the previous claims. Thus, no new matter is added. In view of the amendments and the following remarks, reconsideration and allowance are respectfully requested.

Entry of the amendments is proper under 37 CFR §1.116 since the amendments: (a) place the application in condition for allowance (for the reasons discussed herein); (b) do not raise any new issue requiring further search and/or consideration (since the amendments amplify issues previously discussed throughout prosecution); (c) satisfy a requirement of form asserted in the previous Office Action; (d) do not present any additional claims without canceling a corresponding number of finally rejected claims; and (e) place the application in better form for appeal, should an appeal be necessary. The amendments are necessary and were not earlier presented because they are made in response to arguments raised in the final rejection. Entry of the amendments is thus respectfully requested.

I. Rejection under §103

A. Claims 1-5, 7-8, 10-12 and 14

The Office Action rejects claims 1-5, 7-8, 10-12 and 14 under 35 U.S.C. §103(a) over U.S. Patent No. 5,876,684 to Withers et al. ("Withers") in view of JP 11116218 to Chiharu et al. ("Chiharu"). Applicants respectfully traverse the rejection for at least the following reasons.

Claims 4-7, 10 and 12-14 are canceled thus rendering their rejection moot. Claims 2-3, 8-9 and 11 depend from claim 1. Claim 1 is directed to a method of manufacturing single-walled carbon nanotubes utilizing an arc discharge and a carboniferous liquid state

material, under a pressure of at least 39.9 kPa. Withers and Chiharu do not teach or suggest such a method.

Withers describes a vaporization method for synthesizing fullerenes from a liquid hydrocarbon source using a heat-generating process, such as an electrode arc or plasma. Withers primarily focuses on attempting to overcome the scale-up difficulties of the then known synthesis methods such as graphite rod vaporization. For example, one reported aspect involves supplying a continuous carbon fluid stream to where it is heated and vaporized under a non-oxidizing atmosphere (col. 1, lines 30-47). However, Withers does not teach or suggest any system that favors the formation of single-walled carbon nanotubes as claimed.

Withers focuses on maximizing the production of "fullerenes", without regard to any particular shape or size. The methods described in Withers reportedly produce C_{60}, C_{70} and higher molecular weight fullerene structures that consist of closed structure hexagons and pentagons as well as tubular shapes (col. 2, lines 1-13). Withers discloses systems for vaporizing large quantities of carbon under conditions that "maximize the formation of fullerenes." (col. 2, lines 28-32).

For instance, Withers applies various pressure and temperature controls designed to maximize the formation and yield of fullerenes. In particular, Withers discloses that the processing conditions that surround the carbon particulate during vaporization, i.e., the atmosphere, "are those that are known to stimulate the formation of fullerenes." (col. 2, lines 38-42). Withers reportedly employs temperature "quenching" conditions to "maximize the formation of fullerenes of various molecular weights and structures." (col. 2, lines 45-50).

Withers also discloses a variety of techniques for heating the hydrocarbons to form fullerenes (see, col. 9, lines 40-53), and discloses that the hydrocarbon source can be "any gas, liquid or solid feed to the heating system." (col. 9, lines 60-61). Withers also teaches

that there are "a number of arc configurations which can be used to provide the thermal energy that will pyrolyze hydrocarbons under conditions for the formation of fullerenes." (col. 10, lines 1-3). Finally, in the numerous Examples, Withers utilizes an assortment of various parameter combinations to synthesize fullerenes (col. 13-18). However, throughout the specification, and in the Examples, Withers describes the synthesis of fullerenes without any sort of preference for or discernment between the type of fullerene compound that is produced. Moreover, Withers fails to express any particular variation that favors the production of the single-walled nanotube type of fullerene.

In contrast to Withers, Applicants claim a method that favors, and in fact requires, the production of single-walled carbon nanotubes to the general exclusion of other types of fullerenes. For example, the process of claim 1 specifically features an arc discharge method at a pressure range of at least 39.9 kPa (at least about 300 torr). Dependent claim 11 further limits the claimed pressure range to a well defined and very narrow pressure range of 39.9 kPa to 79.8 kPa (about 300 to 600 torr). Withers on the other hand discloses atmospheric conditions that merely enhance the formation of fullerenes in general and states this to be 10^{-6} to 760 torr, an incredible range stretching over about 9 logs (see, e.g. col. 4, lines 63-66). In no way does Withers teach or suggest anything that would have motivated one of ordinary skill in the art to conduct single-walled nanotube synthesis at a pressure range of at least about 39.9 kPa or the much narrower range of 39.9 kPa to 79.8 kPa.

Moreover, Withers teaches away from the claimed pressure range. In many of the disclosed embodiments, Withers recites a preference for using a pressure of 100-200 torr. (see, e.g., col. 6, line 15; col. 9, line 23; col. 9, line 55; col. 10, line 47). Withers also teaches that much lower pressures, in the range of 10^{-3} to 10^{-6} torr can also be used with "attendant advantages." (col. 9, lines 5-10).

The Office Action asserts that while Withers teaches the use of a broad pressure range of 10^{-6} to 760 torr, the selection of the 39.9 kPa to 79.8 kPa pressure range is the mere "optimization of a known process which could have been determined through routine experimentation." However, whether one of ordinary skill in the art could vary the pressure range and routinely observe the effects thereof is irrelevant to this rejection. Of relevance is that none of the cited references provide any suggestion or motivation for one of ordinary skill in the art to select the claimed pressure range to selectively synthesize single-walled carbon nanotubes, particularly over Withers' disclosure of a preference to produce fullerenes. Withers in particular fails to recite anything that would have taught or suggested raising the pressure 100-200 torr in order to favor the production of single-walled carbon nanotubes.

Chiharu fails to remedy the deficiencies of Withers. Chiharu describes a process for producing carbon nanotubes that focuses on the starting material. Chiharu discloses a variety of processes that utilize for raw material: (1) metal dispersed carbon, (2) metal-carbon combined particles, or (3) metal and methane. However, Chiharu fails to suggest any particular pressure conditions. The methods taught by Chiharu are completely silent as to the use of pressure. In no way does Chiharu teach or suggest the production of single-walled carbon nanotubes at 39.9 kPa to 79.8 kPa, as claimed. For at least the above reasons, the combination of Withers and Chiharu would not have rendered obvious claims 1-3, 8-9 and 11.

As acknowledged in the Office Action, Withers also fails to teach or suggest the formation of single-walled nanotubes using a catalyst within the carbon feed. The Office Action relies on Chiharu for teaching the use of metal catalysts and concludes that it would have been obvious to one of ordinary skill in the art to include the metal catalyst materials in the carbon feed of Withers in order to produce single-walled nanotubes.

Chiharu describes the production of nanotubes by a dry process (e.g., laser beam deposition, arc discharge, induction heating, plasma, etc.) using as a starting material (1) metal dispersed carbon, (2) metal combined carbon particles, or (3) methane and a metal (Abstract). In instances (1) and (2), Chiharu teaches the use of metal/carbon particles with a grain size of 100-10 nm or less (par. 0008). In all three instances, Chiharu teaches various processes to "compound a dry-process carbon nanotube." (par. 0010). The Chiharu embodiments utilizing various dry process methods use a solid carbon target or carbon source such as a graphite rod (par. 0015), a carbon electrode (par. 0016), raw material graphite (par. 0017), or methane (par. 0018 and 0019). Chiharu describes modes for generating the metal/carbon materials (par. 0020-25). However, Chiharu does not teach or suggest the use of a "carboniferous liquid state material comprising a metallic catalyst" as claimed.

Applicants' claimed method for producing single-walled carbon nanotubes includes metal compounds dissolved and/or dispersed into the carboniferous liquid state material, described in the specification at least at page 11. Chiharu fails to teach or suggest supplying this type of source material in the discharge plasma. Thus, the combination of Withers and Chiharu would not have rendered obvious the claimed method of producing single-walled carbon nanotubes.

Accordingly, for all of the above reasons, Applicants respectfully request reconsideration and withdrawal of the rejection of claims 1-3, 8-9 and 11.

B. Claim 6

The Office Action rejects claim 6 under 35 U.S.C. §103(a) over Withers and Chiharu, further in view of U.S. Patent No. 5,227,038 to Smalley et al. ("Smalley"). Applicants respectfully traverse the rejection because the cancellation of claim 6 renders this rejection moot. Accordingly, the rejection should be withdrawn.

C. Claims 9 and 13

The Office Action rejects claims 9 and 13 under 35 U.S.C. §103(a) over Withers and Chiharu, further in view of Journet et al. ("Journet"). Applicants respectfully traverse the rejection.

Claim 9 depends from claim 1 and features ytrrium as the metallic catalyst; claim 13 is canceled. The Office Action relies on Journet to teach the use of yttrium catalysts for increased yield of single-walled carbon nanotubes. Nevertheless, Journet does not remedy the deficiencies of Withers and Chiharu detailed above.

Accordingly, Applicants respectfully request reconsideration and withdrawal of the rejection.

II. Conclusion

In view of the foregoing, it is respectfully submitted that this application is in condition for allowance. Favorable reconsideration and prompt allowance of claims 1-3, 8-9 and 11 are earnestly solicited.

Should the Examiner believe that anything further would be desirable in order to place this application in even better condition for allowance, the Examiner is invited to contact the undersigned at the telephone number set forth below.

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